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MBA PROFESSIONAL REPORT

Optimizing Project Selection at the Department of Public Works, Presidio of Monterey

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December 2012

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Large organizations suffer from the problem of insufficient resources to complete all project requests submitted throughout the year. With the high volume of project requests received and the limited resources available, picking those projects to fund that return the highest value to the organization can be a daunting task. The purpose of this research is to help management make an optimal decision, and determine whether the introduction of an Excel-based optimization model would benefit an organization in its selection process. This research focuses on the project selection process for the Department of Public Works for the Presidio of Monterey Army instillations in the Monterey area. The results from the current fiscal year's selection process are compared with the results from the optimization model. This demonstrates how analytical tools, specifically an optimization model, can add value to an organization by increasing the number of projects selected. One of the conclusions of this thesis is that for the model to properly reflect the values of the organization, a different weighting system would be needed. Therefore, this research recommends that the optimization model be used, but only as a non-biased opinion on which projects should be selected.

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OPTIMIZING PROJECT SELECTION AT THE DEPARTMENT OF PUBLIC WORKS, PRESIDIO OF MONTEREY

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ABSTRACT

Large organizations suffer from the problem of insufficient resources to complete all project requests submitted throughout the year. With the high volume of project requests received and the limited resources available, picking those projects to fund that return the highest value to the organization can be a daunting task. The purpose of this research is to help management make an optimal decision, and determine whether the introduction of an Excel-based optimization model would benefit an organization in its selection process. This research focuses on the project selection process for the Department of Public Works for the Presidio of Monterey Army instillations in the Monterey area. The results from the current fiscal year's selection process are compared with the results from the optimization model. This demonstrates how analytical tools, specifically an optimization model, can add value to an organization by increasing the number of projects selected. One of the conclusions of this thesis is that for the model to properly reflect the values of the organization, a different weighting system would be needed. Therefore, this research recommends that the optimization model be used, but only as a non-biased opinion on which projects should be selected.

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LIST OF ACRONYMS AND ABBREVIATIONS

CSR	Customer Service Representative
DPW	Department of Public Works
IMCOM	Installation Management Command
PMSA	Presidio Municipal Services Agency
POM	Presidio of Monterey
RAC	Risk Assessment Code

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I. INTRODUCTION

This research seeks to aid in the process of project selection when selecting from a large number of projects. These projects range in scope and expense, all with varying values to the organization. Data from the proposed project request forms will be collected and entered into a mathematical model. After all of the data is entered into the model, the model will be run and the results examined.

The purpose of this research was to examine the results produced by the model to gain an understanding of why certain projects were selected or rejected by the model. In addition, the projects selected by the model were compared with the projects selected by the organization to understand why different projects were selected by the organization and model. Finally, an analysis was conducted to determine if a model of this type would be beneficial to add to the project selection process to provide a nonbiased opinion of which projects to select.

A. BACKGROUND

The Department of Public Works (DPW) at the Presidio of Monterey (POM) is responsible for overseeing new construction and rehabilitation of current facilities at several area bases. Some of the bases under the DPW include the Presidio of Monterey, which houses the Defense Language Institute, and the Ord. Military Community, which was part of the former Fort Ord Army base. Currently, it houses military housing communities and some administration groups.

The DPW is divided up into five divisions, each with a focus on a different aspect of maintaining and improving the facilities that fall under its area of responsibility. Those divisions are the Engineering Division, Environmental Division, Housing Division, Master Planning Division, and the Hazardous Waste Management Division. While each division has different responsibilities, each must work together to accomplish the department’s goals.

This research examines projects that are reviewed and approved at the local level. They are paid for out of funds that are appropriated for projects specifically for the DPW at POM. Due to this type of funding, the scope and budget for these projects are very limited and, therefore, only need approval from the base commanding officer.

1. Department of Public Works Project Review

When a problem is discovered requiring repairs or when a small new construction project is needed, the requestor must submit the appropriate request form to begin the consideration process. Project requests are accepted year-round, but are typically not presented to the review board until the following fiscal year.

a. Project Submission and Review

When customers want to submit a project request, they must fill out a DA Form 4283 and submit it to the DPW. The form is submitted to a customer service representative (CSR) of the DPW and the validation process begins. This process ensures that the form has been submitted to the proper department before moving forward.

Once the form has been approved to start the validation process, it goes through several different tests that are all performed by the same CSR. These tests ensure that the request is not covered under other options for repair or replacement. First the request must show that it meets the minimal dollar value of $2,500. If the project does not meet the minimal amount, the request is returned to the customer for submission through the Presidio Municipal Services Agency (PMSA) Portal. The DPW outsources certain work using the PMSA Portal, an online system that submits work request to local cities that are contracted to provide minor repair and general maintenance to area Army bases.

Much of the work performed by the DPW is covered by warranties for a period of time. If the request meets the minimal dollar amount but is found to be covered by a warranty, the project request is sent to PMSA. However, it is the responsibility of the DPW to follow up on these projects to ensure that the warranty work is completed.

Every base has a large number of local contracts to maintain different parts of the bases. These contracts are given to local companies to spread the monetary benefits of having a military installation in the area. These contracts encompass everything from cleaning the buildings to maintaining the landscape. Every work request that comes through the DPW must be compared to these service contracts. If the work is covered by a service contract, the request is passed to the pertinent company to handle the request.

After the project request has made it through all of the different requirement checks, it now becomes a project the DPW must consider. The project request cost is estimated; if the estimate ends up being lower than the minimal dollar threshold ($2,500), and it meets the requirements of the PMSA contract, it is submitted to the PMSA Portal. If the project does not meet the requirements of the PMSA, it is submitted to the operations and management representative to be processed with a government purchase card. If the estimate is above the dollar threshold allowed for the base to fund the project out of its given budget ($750,000), the project is submitted as a military construction request using DD Form 1391.

Finally, the project is scored and when the review board meets, all of the projects submitted are presented for review and selection. Currently, if a project request has reimbursable source funding, the project is automatically selected. Typically, a project will be deemed a reimbursable project later in the process, after the selection process has been completed. The only impact selecting these projects has is on available man-hours, which are used for environmental and engineering studies. Reimbursable projects do not require financial funds from the general budget. The remaining budget is allocated toward projects with the highest scores (or projects deemed important enough). Once the projects are selected, they are moved to the contracting phase.

B. PROJECT SEPARATION

Projects that make it to the selection consideration stage are divided up into two groups. The current range starts at $2,500 and has a ceiling of $750,000. This is a very wide range of projects to consider and value against each other; therefore, the projects are broken up into two price groups. The first group includes all projects falling between the estimated price range of $2,500–25,000. The second range of projects includes all projects falling in the range of $25,000–750,000. This research focuses on all projects being considered for fiscal year 2013 in the second price range ($25,000–750,000).

C. DETERMINING PROJECT VALUE

Determining the value of a project is somewhat of a subjective process. The DPW uses a prioritization matrix that they developed and is updated yearly as the department sees fit. The values from the five categories of the prioritization matrix are added together to gain the project's final value. The prioritization matrix values a project on five different factors:

- Facility Category
- Description of Work
- Risk Assessment Code
- Installation Management Command Objective
- Master Plan Impact

1. Facility Category

The first factor on the prioritization matrix values where the project is being performed and is divided up into six different subcategories. Each of the subcategories receives a separate value, as seen in Table 1. Once the subcategory is picked, the corresponding value is recorded for the facility category.

Table 1. Facility Category Values

Category	Value
◊ Barracks ◊ Utilities ◊ Dining Facilities ◊ Instruction Facilities	25
◊ Child Development Centers ◊ Physical Fitness Centers ◊ Admin, Ops/Training Facilities ◊ EMS Facilities ◊ ACP/Security Fence ◊ Information Mgmt Facilities	20
◊ Medical Facilities ◊ Energy Plants ◊ Fencing/Walls/Gates ◊ Lodging	13
◊Maintenance Facilities ◊ Community Facilities ◊ Roads ◊ Storm Drainage	8
◊ Supply Facilities ◊ Production Facilities ◊ Admin Facilities ◊ Chapels ◊ MP Stations ◊ Parking Paved/Unpaved	5
◊ Grounds ◊ Outdoor Athletic Fields ◊ Parade Fields	3

Note. These values are from the prioritization matrix created by the DPW. The format has been changed to fit the space provided.

2. Description of Work

Determining the type of work that is to take place is very important. Some types of work can be difficult and require complex construction or repair. Table 2 shows the description of work section from the prioritization matrix and the nine subcategories with their corresponding values. After the subcategory is picked, its value is added to the other four prioritization matrix values, after they are selected.

Table 2. Description of Work Values

Category	Value
◊ Structural Repair ◊ Heating Plant Equipment ◊ Cooling Plant Equipment ◊ Electrical Plant Equipment ◊ Traffic Signals ◊ Mold	41
◊ Roof Replacement ◊ Interior Wiring ◊ Fire Protection/Alarm Systems ◊ Emergency Lighting ◊ HVAC/Power Distribution ◊ Security Fence Enhancement ◊ Elevators/Cranes/Hoists ◊ ADA Compliance	37
◊ HVAC Within Building ◊ Building Exterior Lighting ◊ Roads/Pavement /Markings ◊ Interior Wall Repair	31
◊ Stair Treads/Safety Issue ◊ Interior Lighting ◊ Window/Door/Lock Replacement ◊ Plumbing ◊ Underground Tank Removal ◊ Asbestos Abatement ◊ Endangered Species Protection	29
◊ Washracks ◊ Exterior Siding	23
◊ Flooring/Carpet/Tile ◊ Exterior Painting ◊ Ventilating Systems ◊ Drainage/Erosion Controls ◊ Equipment Removal	19

Category	Value
◊ New Construction—Building ◊ Demolition	
◊ Interior Painting ◊ Indoor Courts/Playing Surfaces ◊ Sidewalks ◊ Ceiling Tiles ◊ Mailboxes ◊ Signs ◊ Parking Lot/Marking ◊ Utilities/Meters/UMCS ◊ Fencing	17
◊ Building Additions/Alterations ◊ Building Conversions ◊ BUP/BIP	13
◊ Bleachers ◊ Pressure Wash Exterior ◊ Landscaping ◊ Irrigation Equipment	7

Note. This information is from the DPW's prioritization matrix. The format has been changed to fit the space provided.

3. Risk Assessment Code

Assessing the risk of a project not being completed is vitally important. The Army has developed risk assessment codes (RAC), as seen in Table 3, that are used to determine the level of risk. Each RAC is made up of two different factors that are used to determine the RAC category: the hazard present if the project is not completed and the probability of that hazard taking place if the project is not completed. The proper RAC is selected and the value is added to the other prioritization matrix values to compute the final project value.

Table 3. Risk Assessment Code Values

Category	Value
RAC I: Hazard/Probability ◊Catastrophic/Frequent ◊Catastrophic/Likely ◊Critical/Frequent	41
RAC II: Hazard/Probability ◊Critical/Likely ◊Critical/Occasional ◊Catastrophic/Seldom ◊Moderate/Frequent	31
RAC III: Hazard/Probability ◊Moderate/Likely ◊Moderate/Occasional ◊Critical/Seldom ◊Catastrophic/Unlikely ◊Negligible/Frequent	23
RAC IV: Hazard/Probability ◊Moderate/Seldom ◊Moderate/Unlikely ◊Negligible /Likely ◊Negligible/Occasional	8
Mission Enhancement ◊Not required, but nice to have	0

Note. This section is from the DPW's prioritization matrix. The format has been changed to fit the space provided.

4. Installation Management Command Objective

The Installation Management Command (IMCOM) was developed "to provide the Army with the installation capabilities and services to support expeditionary operations in a time of persistent conflict, and to provide a quality of life for Soldiers & Families commensurate with their service" (*Installation Management Command—PAC*, n.d.). In keeping with the IMCOM's mission statement, guidance has been set for bases to attempt to spend a maximum of 8% of their fiscal budgets on new projects. This guidance provides an emphasis on repair projects to ensure that the bases' facilities are maintained for their users. To ensure that this guidance is incorporated into the valuing of prospective projects, the values in Table 4 have been developed.

Table 4. Installation Management Command Objective Values

Category	Value
◊ Facility Component is failed (Q4/F4).	50
◊ Facility Component is in failing condition (Q3/F3) ◊ Facility Component is past its recommended life ◊ Energy project with an ROI of under five years	30
◊ Facility Component has moderate wear (Q2/F2) ◊ Facility Component is out of code (including new construction) ◊ Energy project with an ROI of under 10 years	10
◊ New Construction ◊ Facility Component has light/no wear (Q1/F1)	0

*Note***.** This section is from the DPW's prioritization matrix. The format has been changed to fit the space provided.

5. Master Plan Impact

Every base has a master plan that has been developed to move the base into the future. It ensures that the base's facilities are updated and utilities are maintained and modernized as needed to support the base's mission. To incorporate the proposed projects' impact on the master plan, a set of values has been developed and can be seen in Table 5. Once the impact is assessed, the value is calculated and added to the other categories to determine the project's final value.

Table 5. Master Plan Impact Values

Category	Value
Project will have a positive impact on meeting goals of Master Plan/ADP.	20
Project will have no impact on meeting goals of Master Plan/ADP.	0
Project will have a negative impact on meeting goals of Master Plan/ADP.	-20

Note. This section is from the DPW's prioritization matrix. The format has been changed to fit the space provided.

6. Final Calculation of Project Value

The final value calculation is as follows: Facility Category Value + Description of Work Value + RAC + Installation Management Command Value + Master Plan Impact Value = Final Project Value.

Once the value is calculated, it is assigned to the project. Some debate can take place over the final value if there are questions over the validity of the value. This process is repeated for all of the proposed projects.

D. RESEARCH AND SCOPE

Although the DPW has a decent method for selecting projects, several components of these projects are not considered by the review board. Currently, neither environmental man-hours nor engineering man-hours are incorporated at any point in the selection process, but could be two of the driving factors on project completion. Not having enough man-hours to complete projects would prevent them from being completed. In addition, no cost-benefit analysis is performed on the different projects.

In addition to ignoring these two constraints, all of the projects must be compared to one another manually. When dealing with a large number of projects, this may take a lot of time that could be spent better elsewhere. This also introduces the chance for human error when comparing the projects and the possibility of personal biases when selecting projects.

In this research project, I developed an Excel-based mathematical model to assist the DPW in its process selection. The model incorporates the constraints of the financial budget, environmental and engineering man-hours, and the amount of the budget spent on new projects, while maximizing the value of all the projects selected. The model could be used as an aid to the DPW, providing a non-biased method for determining which projects to select.

The remaining research is divided up into five chapters as follows. In Chapter II, I review literature on project valuing and selection. Chapter III explains the data collection methods used to collect data and what data is collected. In Chapter IV, I discuss the development of the model and the model itself. Chapter V analyzes the results presented by the model and compares those results to the projects selected by the DPW. In Chapter VI, I will provide conclusions and recommendations for future research.

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II. LITERATURE REVIEW

Currently, the DPW uses a variation on project selection by scoring to pick projects to move forward with into the contracting phase. Unlike larger military construction projects that must be sent to Congress for approval, this research focuses on smaller tasks across the different branches that do not have set approval requirements. This chapter reviews literature on the topics of the knapsack problem, decision modeling, valuing projects, and project selection.

A. THE KNAPSACK PROBLEM

The knapsack problem has been around for decades and can be used for a wide variety of situations. In one way, based on the types of results a knapsack problem produces, it can be called the “science of better” (Goulimis, 2007). It is the science of picking the best solution based on the information available.

The knapsack problem can be illustrated as a person getting ready to go on a camping trip. To prepare for the trip, they must determine what to pack in their knapsack to take with them. A knapsack can only carry so many items before it is full or too heavy to carry. This limitation forces the person to decide what will be of most benefit on the trip. The person traveling is creating the best value of items packed for the trip. This is the basic concept of a knapsack problem: choose the items which produced the highest value to the user (Martello & Toth, 1990).

Using a knapsack-type approach to project selection is one of the easiest was to choose projects in the military. This is due to the way which the military general sets its budgets. A project being submitted for selection has a set budget, a value associated with the proposal, and a set of binary options, typically to accept or reject the proposal. In addition, the military has set limits on the resources it has to spend on different projects. This is where the theory of a knapsack problem comes into play. The projects with the highest combined value within the limitations are chosen to produce the greatest value to the consumer (Brown, Dell, & Newman, 2004).

B. DECISION MODELING

Making decisions is hardly ever an easy task, and many have tried to find ways to make those decisions easier. Balakrishnan, Render and Stair explain their decisions making process. "Regardless of the size and complexity of the decision-making problem at hand, the decision modeling process involves three distinct steps: (1) formulation, (2) solution, and (3) interpretation" (Balakrishnan, Render, & Stair, 2003, p. 6).

1. Formulation

Formulation is the key building block for developing a successful decision model. If this step is skipped or not given the time it needs, issues could develop when formulating the actual decision model. This is the point in the process where the problem needs to be analyzed and mathematical values determined. If this process is not followed, or the problem is not fully analyzed, it can create additional problems in the decision model. The importance of formulation is very clear; the purpose of the formulation is to ensure the mathematical model developed will completely addresses all the issues related to the problem being solved. To aid in a better understanding of the formulation process, it should be divided up into three separate steps: defining the problem, developing a model, and acquiring input data.

a. Defining the Problem

The first step in formulating a decision model is defining the problem. This is one of the most important steps in the formulation process, but it tends to be one of the most difficult parts of formulating a decision model. It is important to ensure that the problem is being fully analyzed. If the problem is only examined on the surface, the true problem could be missed. If only a surface problem is solved and the connecting problems are not identified and solved, the solution the decision model produces may not be the appropriate solution and could create additional problems. The authors explain why this is an important step. "Thus, it is important to analyze how the solution to one problem affects other problems or the decision-making environment in general. Experience has shown that poor problem definition is a major reason for failure" (Balakrishnan, Render, & Stair, 2003, p. 7).

b. Developing a Model

Once the problem has been fully defined and all associated problems have been solved, it is time to develop the model. Many types of models can be used to solve problems or illustrate the final solution. One option is a decision model. A decision model is set apart from other modeling techniques because it is a mathematical model and is based on mathematical relationships. These models are typically designed on paper then run in Excel because of the number of mathematical equations involved.

According to Balakrishnan, Render, and Stair (2003), these are flexible models that contain at least one or more variables, commonly known as decision variables. The models may be flexible, but they must be solvable, based in reality, not overly complicated, and easy to modify. In addition, the data needed for the model must be available. A developer must be careful to ensure that the model has enough detail to produce appropriate results, yet is not burdened by too much detail. A model with too many constraints (details) may not produce an optimal solution.

When developing a model, three key components of the model must be determined. First, the decision variables must be picked. These are typically unknown entities, representing the question of how many products to produce of an item or which projects to accept or reject. Once the decision variables are selected, the objective function or the answer to what is being solved can be developed. An example of an objective function is setting up the model to solve the mathematical equation of how to produce the most profits or to maximize the value to an organization. However, it would be impossible to find a solution without constraints. Constraints are the final piece of the model, and they place limits on the number of items that can be produced, or the number of projects accepted. Constraints enforce limits on the amount of valuable resources being allocated.

c. Acquiring Input Data

A developer can design the perfect model, but with poor information the model would be completely useless. It is vital that the proper information is collected to prevent the results from being misleading. This reinforces the idea that if the data started with is garbage, the final results will be garbage. Information can be collected from a multitude of sources, such as measuring the amount of raw material used at a plant compared to the amount of product being produced or surveying a shop floor supervisor who would be a subject-matter expert.

2. Solution

In the past, this was the part of the process that took the longest to complete. With the development of modern computers and Excel, solving the mathematical equations is now one of the quickest parts of the process. The solution should be divided up into two parts: developing a solution and testing the solution

a. Developing a Solution

Developing the final solution can be accomplished in a couple of different ways. One example of solving the problem is the trial-and-error method. This method looks at all of the possible solutions and then picks the one that satisfies the mathematical model the best. Modern technology has sped up this part of the process dramatically. Once the information has been entered into the model, the model is run and a solution is produced.

b. Testing the Solution

Before the solution can be implemented, it should be tested to ensure that it performed properly. The model uses data entered by outside parties; therefore, human error is possible. One way to test the solution provided by the model is against historical data. If the solution does not seem to match up with independent data collected, or it seems that the solution is inconsistent, the model should be examined for errors to ensure that it produces an optimal solution.

3. Interpretation and Sensitivity Analysis

Once a solution is produced by the mathematical model, the user must decide what to do with the information. The user needs to analyze the results and then possibly perform a sensitivity analysis.

a. Analyzing the Results

The user must examine the results produced by the mathematical model. The impact of the solution on the organization must be determined. Some changes may not be beneficial for the organization because their impact may have a negative impact on other parts of the organization.

b. Sensitivity Analysis

Organizational leaders my ask questions regarding why one would want to perform sensitivity analysis. The purpose of performing sensitivity analysis on the results is to see how much the final solution will differ depending on changes made to the mathematical model. Balakrishnan, Render, and Stair (2003) explain three different types of sensitivity analysis.

Changing the objective function can change the output of the model, but researchers must determine by how much. Users trying to maximize profits may change the cost of an item, such as a chair. The user can then rerun the model and compare the changes to the final solution. If the final solution does not change much, then it is evident that the change has not affected the final solution much; therefore, it could be said that the solution has low sensitivity to the changed variable. If the final solution changes a significant amount, then it is evident that the solution has high sensitivity to the variable changed.

It is also possible to make changes to the right-hand side of the constraint equation. This side of the constraint equation limits the amount of resources available, or ensures that only a certain amount of something is produced. Making more or less of a resource available could have a dramatic effect on the final solution. If the change is dramatic, then it is clear that the solution is very sensitive to changes in the amount of resources available. If the change is small, or if it causes no change to the final solution, then it has low sensitivity to that resource.

The final part of the mathematical model that can be changed is the left-hand side of the constraint section. This is the part of the mathematical model that tells how much of a certain resource each item uses. For example, if item A uses 20 pounds of a certain raw material, but only 100 pounds are available, then a maximum of five items could be produced. Changing the amount of raw materials used by each item could drastically change the final solution. If the change is dramatic, then the final solution is sensitive to that constraint. If the change is small, then there are other constraints that have a larger impact on the final solution.

C. DETERMINING PROJECT VALUE

Determining a project value correctly is key to ensuring that vital resources are allocated appropriately. Everything uses resources and how some of those resources are allocated can be determined by policy. "Public policies usually require resources (i.e., inputs) that could be used to produce other goods or services instead. Public works projects such as dams, bridges, highways and subway systems, for example, require labor, materials, land and equipment" (Boardman, Greenberg, Vining, & Weimer, 2001, p. 99). All of these resources are limited; once a decision has been made to allocate them, they are no longer available for allocation to other projects.

1. Opportunity Costs

Many times, projects are valued only on one aspect of the project, the direct budgetary outlay. This works for many projects that do not require the purchasing agency to take into account other costs. Under some circumstances, the direct budgetary outlay is also identical to the conceptual opportunity cost, but, under other circumstances, the two are not equal and the difference should be considered.

2. Distributional Weights

Some projects have multiple inputs that should be considered when valuing a project. Some companies take into account the project's location, the risk if the project is not completed or the risk it currently possesses, and the type of work that must be completed. The following question arises: How can all of these variables be incorporated into a value the user is satisfied with?

One way to solve the issue of having multiple inputs for valuing a project is to use distributional weights. Inputs can be treated differently by assigning different weights. Some of these weights can be as simple as 1, 2, or 3, but they should reflect the intended value. By giving weights to different factors, a group can value multiple factors in a way it deems appropriate. It can use these weights to give values to different projects or groups, then compare how they rank against each other. "Obviously, developing weights that allow a single quantitative criterion for ranking alternative policies makes the choice among policy alternatives easier" (Boardman et al., 2001, p. 46).

Valuing projects can be a difficult task to complete especially when more than one person is involved. "The obvious difficulty with implementing this approach is determining appropriate weight for each group. The weights should, of course, be consistent with the rationale for using them" (Boardman et al., 2001, p. 497). If the group is unable to settle on appropriate weights to be used in the valuing process, then the project selection process will not select projects that provide the greatest benefit to the organization.

3. Peer-Review Evaluation Questionnaire

Peer-review questionnaires are another way of determining the value of a given project. A questionnaire is developed with six different questions the cover the four basic R's: "one question each for relevance, risk, and reasonableness and one each for the three kinds of return" (Henriksen & Traynor, 1999, p. 163). The answers are each given a different point value. *Very low* is given one point and *very high* is given five points. Typically the scale of zero to four (when using a five point value scale) should be avoided so that the zero does not cause mathematical difficulties. This type of evaluation is easy to use and gives designers flexibility when designing the questionnaire. Each question can be tailored to the needs of the organization.

D. PROJECT SELECTION

With the limited resources available to government agencies today and the growing number of projects needed to maintain the current infrastructure, selecting the best projects is all that more important. When selecting projects, the proper selection process must be used to ensure that the needs of the organization are met. Hundreds of studies have been published on project selection, dating back for more than 50 years and illustrating many different approaches. According to Henirksen and Traynor (1999), these "approaches tend to be either quantitative and qualitative, ranging from rigorous operations research methods to social-science-based interactive techniques" (p. 158). The authors (Henriksen & Traynor, 1999) go on to list more than 55 different ways to perform project selection. Many of the options listed are very similar, but with minor differences. This review looks at what Henriksen and Traynor (1999) say about project section using a practical project-selection scoring tool.

1. Project Selection Using Scoring

Using scoring for project selection is appropriate when there is a low degree of interdependence between projects. A common approach for rating potential projects is against a value matrix or a set criterion. Researchers using this approach first obtain a value for each category, and then combine the scores through an equation to arrive at a final value. If certain parts of the rating need to be emphasized (or deemphasized), those parts can be given a weight that will increase (or decrease) value compared to the other criteria being rated. These methods are traditionally purely additive or multiplicative, which means simply adding up the values obtained from the ratings or multiplying the values.

Using this type of scoring to pick a project is one of the easier methods used. "It is quantitative enough to possess a certain degree of rigor, yet not so complex as to mystify and hence discourage potential users" (Henirksen & Traynor, 1999, p. 162). In addition, a major benefit to using scoring as a method to value projects is that it gives a quantitative score to criteria that is not quantitative. This enables users to debate the values given to different criteria and ensure that the values represent the organization's priorities while providing a fully customizable tool.

Scoring is an easy method for ranking projects; it does have a few drawbacks that should be considered. First, while a project may be selected by rating the different projects' scores, these scores may not represent the actual value of the project. Second, scores that are purely additive or multiplicative cannot show the trade-offs given up when one project is chosen over another. Finally, when developing scores, it can cause some animosity between individuals submitting the projects and those involved in the project-selection process.

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III. METHODOLOGY

There are many different ways to select projects to move forward to the contracting stage. The question is which projects should be chosen to provide the greatest benefit to the organization. Every organization has different needs and goals. The one common theme all organizations have is a limited amount of resources they can use to complete projects. Because of these limitations, an optimization model can be used to maximize the value of projects selected.

A. OPTIMIZATION

Optimization is a methodology of allocating scarce resources to competing activities. Typically for this to be successful, a value must be placed on the competing activities. For solutions to be found, an Excel model can be developed that takes into account all of the resources being spread among competing activates.

This type of activity ensures that the organization selects projects adding the greatest value. This is why it is important to ensure that each project is given a proper value. If projects are not given proper values, or if the values are too close together, the results returned may not pick the best projects. Optimization works by looking at all of the available resources and the amount of those resources that is currently free. It then looks at all the activities that are competing for those resources and the resource amounts they are trying to acquire.

The Excel-based optimization model starts with a comparison of all of the activities competing for resources. It looks at the value of a project compared to the other projects. It also takes into account the amount of resources necessary to complete each activity. The model then runs a variety of tests, selecting different combinations of projects and adding up the values. It runs a multitude of tests until it has found the greatest value of projects selected. The benefit of using an Excel-based model to optimize a solution is the speed at which a computer can calculate all of the possibilities.

B. DATA

Without data, research would not be possible. Data is the backbone of everything we do in our day-to-day lives. All of the things around us have been developed through different types of data that has been collected and used to convince us to purchase items, or is used to make projects work. Data is nothing more than information that is collected and analyzed, so that the results can be used for different purposes. The toughest challenge about data gathering is ensuring that the appropriate data is collected.

1. Data Collection

Data collection can be a difficult task for a researcher. A researcher must ensure the data is collected properly, so that it is not contaminated or infused with unneeded information. The majority of the DPW's data are submitted to the department when work requests are submitted for consideration. Once the department has the work requests, each request is scored and given a value. To collect the data, all of the project requests are reviewed and the information needed is gathered. The needed information is compiled into a list to be entered into the model.

2. Proper Data

The DPW receives a lot of information in the project request forms. However, only certain information needs to be extracted to enable the model to work properly. After the project requests have been scored, the needed information can be extracted and put into the model. For the model to run properly, the following information needs to be gathered from the project request forms: the estimated budget, the estimated environmental and engineering hours, the five scores used to calculate the project's final value, and the project's status as reimbursable or non-reimbursable. The collected data can be seen in Table 6. All projects reviewed in this research were categorized as non-reimbursable; therefore, the reimbursable project column has been removed from all data tables.

Table 6. Project Data

Project Title	Project Type	Project Cost	Est. Eng Hours	Est. Env Hours	Project Priority	Project Value
Project 1	Repair	$200,000	80	X	1	104
Project 2	Repair	$40,118	45	X	1	115
Project 3	New	$31,664	45	X	1	98
Project 4	New	$70,000	45	X	1	95
Project 5	New	$135,171	45	X	1	93
Project 6	Repair	$100,000	45	X	1	92
Project 7	Repair	$110,000	45	X	1	92
Project 8	New	$120,000	45	X	1	92
Project 9	Repair	$71,195	45	X	1	89
Project 10	New	$330,000	80	X	1	87
Project 11	Repair	$60,464	45	X	1	87
Project 12	New	$86,736	8	X	1	80
Project 13	Repair	$72,580	45	X	1	78
Project 14	New	$109,136	45	X	1	78
Project 15	Repair	$157,230	80	X	1	75
Project 16	Repair	$46,288	45	X	1	75
Project 17	New	$250,000	80	X	1	74
Project 18	Repair	$107,700	8	X	1	74
Project 19	Repair	$200,482	200	X	1	74
Project 20	Repair	$448,160	80	X	1	72
Project 21	Repair	$672,352	80	X	1	72
Project 22	Repair	$650,000	80	X	1	64
Project 23	New	$181,618	80	X	1	72
Project 24	New	$129,727	80	X	1	72
Project 25	New	$181,618	80	X	1	72
Project 26	New	$92,623	45	X	1	69
Project 27	Repair	$94,000	45	X	1	69
Project 28	Repair	$715,920	200	X	1	67
Project 29	New	$75,875	45	X	1	67
Project 30	Repair	$350,000	80	X	1	67
Project 31	Repair	$512,822	45	X	1	66
Project 32	New	$229,000	80	X	1	65
Project 33	Repair	$60,863	8	X	1	65
Project 34	Repair	$60,000	45	X	1	65
Project 35	Repair	$84,646	8	X	1	64
Project 36	Repair	$396,260	16	X	1	62
Project 37	Repair	$396,260	16	X	1	62
Project 38	New	$60,000	45	X	1	62

Project Title	Project Type	Project Cost	Est. Eng Hours	Est. Env Hours	Project Priority	Project Value
Project 39	New	$700,000	200	X	1	42
Project 40	Repair	$352,898	45	X	1	60
Project 41	Repair	$146,000	45	X	1	60
Project 42	New	$90,000	45	X	1	57
Project 43	Repair	$462,800	80	X	1	57
Project 44	Repair	$116,350	8	X	1	57
Project 45	New	$44,920	8	X	1	57
Project 46	Repair	$88,057	16	X	1	57
Project 47	Repair	$160,509	45	X	1	57
Project 48	New	$629,132	80	X	1	56
Project 49	New	$629,024	80	X	1	56
Project 50	Repair	$76,320	8	X	1	55
Project 51	Repair	$71,331	8	X	1	54
Project 52	Repair	$85,122	8	X	1	54
Project 53	Repair	$189,640	16	X	1	54
Project 54	Repair	$340,000	16	X	1	52
Project 55	Repair	$82,838	8	X	1	52
Project 56	Repair	$82,838	8	X	1	52
Project 57	Repair	$446,512	40	X	1	52
Project 58	New	$80,000	8	X	1	52
Project 59	Repair	$84,400	8	X	1	49
Project 60	Repair	$100,000	8	X	1	47
Project 61	New	$300,000	80	X	1	46
Project 62	Repair	$70,000	8	X	1	45
Project 63	New	$63,576	45	X	1	45
Project 64	New	$240,000	80	X	1	44
Project 65	Repair	$73,443	45	X	1	42
Project 66	Repair	$97,222	8	X	1	42
Project 67	Repair	$250,000	80	X	1	40
Project 68	New	$720,000	45	X	1	38
Project 69	Repair	$29,780	8	X	1	37
Project 70	New	$43,717	45	X	1	35
Project 71	Repair	$477,718	16	X	1	32
Project 72	New	$45,815	80	X	1	32
Project 73	New	$662,945	80	X	1	22
Project 74	New	$29,915	45	X	1	21
Project 75	New	$75,000	80	X	1	20
Project 76	New	$25,224	45	X	1	18
Project 77	Repair	$82,098	80	X	1	2

Project Title	Project Type	Project Cost	Est. Eng Hours	Est. Env Hours	Project Priority	Project Value
Project 78	New	$28,500	8	X	1	2
Project 79	New	$81,120	80	X	1	-2
Totals	**46R/33N**	**$16,145,272**	**3,980**	**X**		**4,676**

Note. Data were gathered from project request forms. The scores used to produce the final score and reimbursable projects column were removed. In addition, estimated environmental hours (Est. Env. Hours) were not gathered due to a change in the department for this fiscal year.

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IV. MODELING

Developing the proper model can be a tedious task. If the model is not designed properly, it will yield suboptimal solutions. In addition, when dealing with larger models, equations can sometimes contain errors or functions may not be entered correctly, causing the model not to work. In this chapter, I describe the development and use of the mathematical model and the user interface.

A. DEVELOPMENT

To design the model, a two-pronged approach was used, which included the basic mathematical model and a user friendly interface. The mathematical model is a traditional optimization model. The user friendly interface was designed to allow users unfamiliar with Excel optimization models to enter information easily and to run the model in a variety of scenarios to see how changes would affect the final solution.

To develop the program, the mathematical model must first be developed and proven to work before the interface can be developed. The first step in developing the model is to determine its three parts: (1) what will be the values of decision variables and what role will they play in the decision; (2) will the model maximize or minimize a value for the objective function; and (3) how should the constraints be structured to ensure the limits on the available resources are properly enforced.

Determining how the decision variables will be structured is the next step. Are the decision variables going to represent the number of products that should be purchased or are the decision variables going to represent if a project should be selected and therefore considered a binomial, meaning simply a zero or one? Each number would represent something different, such as selecting or rejecting a project. In the research on the DPW selection model, a binominal decision variable was used.

After the type of decision variables have been chosen, the equation for the objective function can be determined. This function can be one of two types, either a maximization or a minimization equation, based on what the model is trying to find. For example, is the model trying to save money or is it trying to maximize the return on the money being spent (or maximize the value of projects selected). The DPW is attempting to maximize the value of projects selected to move forward to the contracting phase. Therefore, this equation would be designed to maximize the total value of projects selected. The equation is designed to instruct the model to run different tests until the combination of projects with the highest value is selected.

The constraint section is the last part of the mathematical model to develop. First, the constraints must be identified. To do this, a sample of projects is analyzed to determine which resources are common among all sampled projects and which of those resources are limited. Once this is determined, the amount or resources should be determined. A couple of other constraints to consider could be if a specific number of items need to be produced, or if only a certain amount of a resource can be spent on the production of a product. After the constraints are chosen, their respective equations need to be produced.

The final step in completing the constraint section is identifying an equation type for each constraint. This is important because if the wrong type of equation is used, the results of the model could change drastically. The equation can be one of three major types: greater than or equal to, equal to, or less than or equal to.

In the case of the DPW, all of the constraints had the same type of equation. Each resource, financial budget, dollar amount spent on new projects, and engineering and environmental hours had an upper limit that could not be passed. All of the constraint equations were less than or equal to equations. Once all the information is collected and the mathematical model is built in Excel, the information can be entered and a solution produced.

B. ASSUMPTIONS

Many assumptions are taken into account once the model itself is run. The major assumptions are that the scoring matrix used to value the projects has been agreed upon by the department to satisfy its requirements. All other assumptions are carried out by the user interface to ensure that all necessary data are appropriately entered into or removed from the mathematical model.

C. MATHMATICAL MODEL

The mathematical model is the centerpiece of the research. Using this model, the data gathered was inputted and the final solution produced. This section is divided into three sections: decision variables, objective function, and constraints.

1. Decision Variables

$$X_i = \begin{cases} 1, if\ project\ is\ selected \\ 0, otherwise \end{cases}$$

i = 1, 2, …, 45, 46 (Repair Projects)

i = 47, 48, …, 78, 79 (New Projects)

2. Objective Function

Maximize

$$V_1 X_1 + V_2 X_2 \ \ldots. + V_{149} X_{149} + V_{79} X_{79} \ ,$$

where V_i is equal to the value of project *i*.

3. Constraints

a. Financial Budget

$$C_1 X_1 + C_2 X_2 \ldots. + C_{45} X_{45} + C_{46} X_{46} <= FB,$$

where *FB* is the available financial budget, and C_i is the cost for project *i*.

b. New Project Expenditure Budget

$$C_{47} X_{47} + C_{48} X_{48} \ldots. + C_{78} X_{78} + C_{79} X_{79} <= FB * P,$$

where P is the percent set for new project expenditure.

c. Engineering Hour Budget

$$EN_1 X_1 + EN_2 X_2 \ldots. + EN_{78} X_{78} + EN_{79} X_{79} <= ENHB,$$

where *ENHB* is the engineering hour budget and EN_i is the estimated number of hours project *i* would require.

d. Environmental Hours Budget

$$EV_1 X_1 + EV_2 X_2 \ldots + EV_{78} X_{78} + EV_{79} X_{79} <= EVHB,$$

where *EVHB* is the environmental hour budget, and EV_i is the estimated number of hours project *i* would require.

V. RESULTS AND ANALYSIS

In this chapter, I present the results and analyze the selected and rejected projects. This chapter explains why the model selected specific projects, and how the projects selected by the model differ from those selected by the DPW.

A. RESULTS

1. Projects Accepted by the Model

The model was populated with FY 2013 estimated data for a financial budget of \$3.2 million, an engineering hours budget of 2,500 hours, and a maximum new project budget of 8% or \$256,000. Data for 79 (46 Repair and 33 New) projects were entered into the model for comparison. After the first run, the model found a solution, selecting 35 (30 Repair and five New) projects, obligating \$3,172,495 of the overall financial budget, 1,224 engineering hours, and \$250,301 (97.7%) of the allotted new project budget. Table 7 shows the projects selected by the model.

Table 7. Project Data Accepted by the Model

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value	Accept Project
Project 1	Repair	\$200,000	80	X	104	Yes
Project 2	Repair	\$40,118	45	X	115	Yes
Project 3	New	\$31,664	45	X	98	Yes
Project 4	New	\$70,000	45	X	95	Yes
Project 6	Repair	\$100,000	45	X	92	Yes
Project 7	Repair	\$110,000	45	X	92	Yes
Project 9	Repair	\$71,195	45	X	89	Yes
Project 11	Repair	\$60,464	45	X	87	Yes
Project 13	Repair	\$72,580	45	X	78	Yes
Project 15	Repair	\$157,230	80	X	75	Yes
Project 16	Repair	\$46,288	45	X	75	Yes
Project 18	Repair	\$107,700	8	X	74	Yes

Project 19	Repair	$200,482	200	X	74	Yes
Project 27	Repair	$94,000	45	X	69	Yes
Project 33	Repair	$60,863	8	X	65	Yes
Project 34	Repair	$60,000	45	X	65	Yes
Project 35	Repair	$84,646	8	X	64	Yes
Project 38	New	$60,000	45	X	62	Yes
Project 41	Repair	$146,000	45	X	60	Yes
Project 44	Repair	$116,350	8	X	57	Yes
Project 45	New	$44,920	8	X	57	Yes
Project 46	Repair	$88,057	16	X	57	Yes
Project 47	Repair	$160,509	45	X	57	Yes
Project 50	Repair	$76,320	8	X	55	Yes
Project 51	Repair	$71,331	8	X	54	Yes
Project 52	Repair	$85,122	8	X	54	Yes
Project 53	Repair	$189,640	16	X	54	Yes
Project 55	Repair	$82,838	8	X	52	Yes
Project 56	Repair	$82,838	8	X	52	Yes
Project 59	Repair	$84,400	8	X	49	Yes
Project 60	Repair	$100,000	8	X	47	Yes
Project 62	Repair	$70,000	8	X	45	Yes
Project 65	Repair	$73,443	45	X	42	Yes
Project 69	Repair	$29,780	8	X	37	Yes
Project 70	New	$43,717	45	X	35	Yes
Totals	**35 Proj Accepted**	**$3,172,495**	**1,224**	**X**	**2,337**	**35**

2. Projects Rejected by the Model

Of the 79 projects examined, 44 (16 Repair and 28 New) were rejected. The projects that were rejected ranged in point value and cost along the entire spectrum. The rejected projects are listed in Table 8.

Table 8. Projects Rejected by the Model

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value	Accept Project
Project 5	New	$135,171	45	X	93	No
Project 8	New	$120,000	45	X	92	No
Project 10	New	$330,000	80	X	87	No
Project 12	New	$86,736	8	X	80	No
Project 14	New	$109,136	45	X	78	No
Project 17	New	$250,000	80	X	74	No
Project 20	Repair	$448,160	80	X	72	No
Project 21	Repair	$672,352	80	X	72	No
Project 22	Repair	$650,000	80	X	64	No
Project 23	New	$181,618	80	X	72	No
Project 24	New	$129,727	80	X	72	No
Project 25	New	$181,618	80	X	72	No
Project 26	New	$92,623	45	X	69	No
Project 28	Repair	$715,920	200	X	67	No
Project 29	New	$75,875	45	X	67	No
Project 30	Repair	$350,000	80	X	67	No
Project 31	Repair	$512,822	45	X	66	No
Project 32	New	$229,000	80	X	65	No
Project 36	Repair	$396,260	16	X	62	No
Project 37	Repair	$396,260	16	X	62	No
Project 39	New	$700,000	200	X	42	No
Project 40	Repair	$352,898	45	X	60	No
Project 42	New	$90,000	45	X	57	No
Project 43	Repair	$462,800	80	X	57	No
Project 48	New	$629,132	80	X	56	No
Project 49	New	$629,024	80	X	56	No
Project 54	Repair	$340,000	16	X	52	No
Project 57	Repair	$446,512	40	X	52	No
Project 58	New	$80,000	8	X	52	No
Project 61	New	$300,000	80	X	46	No
Project 63	New	$63,576	45	X	45	No

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value	Accept Project
Project 64	New	$240,000	80	X	44	No
Project 66	Repair	$97,222	8	X	42	No
Project 67	Repair	$250,000	80	X	40	No
Project 68	New	$720,000	45	X	38	No
Project 71	Repair	$477,718	16	X	32	No
Project 72	New	$45,815	80	X	32	No
Project 73	New	$662,945	80	X	22	No
Project 74	New	$29,915	45	X	21	No
Project 75	New	$75,000	80	X	20	No
Project 76	New	$25,224	45	X	18	No
Project 77	Repair	$82,098	80	X	2	No
Project 78	New	$28,500	8	X	2	No
Project 79	New	$81,120	80	X	-2	No
Totals	**44 Proj Rejected**	**$12,972,777**	**2,756**	**X**	**2,339**	**44**

B. ANALYSIS

The model is designed to maximize the total value of the projects selected, based on a set of constraints determined earlier in section IV. When one of the constraints starts to run low, the model attempts to pick as many projects as possible to maximize the overall value. To start the analysis of the results produced by the model, the projects need to be broken into two different groups, new projects and repair projects.

1. New Projects

New projects have a much smaller financial budget than the repair projects because of the constraint placed on them by the organization. Both new and repair projects pull from the financial budget, but new projects have a cap currently set at 8% or $256,000. With a limited budget, any new project whose cost exceeds the allotted budget is rejected. This budget constraint removed seven new projects (Projects 10, 39, 48, 49, 61, 68, and 73) from the list, leaving 26 projects for the model to consider. Table 9 shows the remaining projects.

Table 9. Revised List of New Projects

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 3	**New**	**$31,664**	**45**	**X**	**98**
Project 4	**New**	**$70,000**	**45**	**X**	**95**
Project 5	New	$135,171	45	X	93
Project 8	New	$120,000	45	X	92
Project 12	New	$86,736	8	X	80
Project 14	New	$109,136	45	X	78
Project 17	New	$250,000	80	X	74
Project 23	New	$181,618	80	X	72
Project 24	New	$129,727	80	X	72
Project 25	New	$181,618	80	X	72
Project 26	New	$92,623	45	X	69
Project 29	New	$75,875	45	X	67
Project 32	New	$229,000	80	X	65
Project 38	**New**	**$60,000**	**45**	**X**	**62**
Project 42	New	$90,000	45	X	57
Project 45	**New**	**$44,920**	**8**	**X**	**57**
Project 58	New	$80,000	8	X	52
Project 63	New	$63,576	45	X	45
Project 64	New	$240,000	80	X	44
Project 70	**New**	**$43,717**	**45**	**X**	**35**
Project 72	New	$45,815	80	X	32

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 74	New	$29,915	45	X	21
Project 75	New	$75,000	80	X	20
Project 76	New	$25,224	45	X	18
Project 78	New	$28,500	8	X	2
Project 79	New	$81,120	80	X	-2
Totals	**5 Proj Selected**	**$250,301**	**188**	**X**	**347**

Note. This table does not include projects with a cost greater than $256,000. All projects selected by the model have been bolded and their values have been totaled at the bottom of the table.

Of the remaining 26 projects, only five were selected (Projects 3, 4, 38, 45, and 70). The total of the five projects selected had a value of 347 points. These five projects consumed a total of $250,301 of the $256,000 available for new projects (leaving $5,699).

This model was small enough that it was possible to look at the results to determine if any other options would have produced a better value. The two new projects with the highest point values are Project 3 (98 points) and Project 4 (95 points). Combined, they produce a value of 193 while only spending a total of $101,664. With both of those values in mind, a comparison and contrast of the remaining projects should be conducted.

One comparison could be made between Projects 3 and 4 and Project 5, which was not selected. Project 5 has a value of 93 and a cost of $135,171. Project 5 is almost even in terms of the value it provides to the organization; however, it consumes more of the financial budget. The computer does not consider the importance of an individual project when selecting projects; rather it maximizes the total value based on the combined total of the selected projects.

This can be demonstrated by using Project 5 as an example. To fund Project 5, $131,670 would have to be added to the budget if all the currently selected projects were kept. If that was not an option, another option is that the remaining three currently selected projects could be deselected and all of the funds transferred to Project 5. The remaining three projects (Projects 38, 45, and 70), plus the budget not allocated after the selection process, would give a total available budget of $154,336. This is enough money to cover the cost of Project 5 and leave a remaining $19,165 available for allocation to another project. As an individual project, it is considered a higher value project than the three selected projects.

The problem with choosing Project 5 over the three selected projects is apparent when the overall value of all selected projects is analyzed. The overall value for new projects selected is 347 points. With the selection of Project 5 and the rejection of Projects 38, 45 and 70, the overall value is decreased by 61 points to an overall value of 286 points. This is why Project 5 was rejected. By selecting Project 5, the majority of the financial budget would be expended and the overall value of all the new projects selected would decrease. This type of selection violates the objective function of the model.

2. Repair Projects

Repair projects have the ability to pull from the entire financial budget. They are not limited like the new projects. The only financial limit placed on them is the overall budget of $3.2 million. Having such a high budget gives all of the projects submitted for consideration an opportunity to be selected. In total, 46 projects were considered by the model to be moved to the contracting phase. Of those 46 projects, 30 projects were selected and 16 projects were rejected. The 30 selected projects expended a budget of $2,922,194 and produced an overall value of 1,990 points. Table 10 shows all repair projects with the model-selected repair projects in bold.

Table 10. All Repair Projects

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 1	**Repair**	**$200,000**	**80**	**X**	**104**
Project 2	**Repair**	**$40,118**	**45**	**X**	**115**
Project 6	**Repair**	**$100,000**	**45**	**X**	**92**
Project 7	**Repair**	**$110,000**	**45**	**X**	**92**

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 9	**Repair**	**$71,195**	**45**	**X**	**89**
Project 11	**Repair**	**$60,464**	**45**	**X**	**87**
Project 13	**Repair**	**$72,580**	**45**	**X**	**78**
Project 15	**Repair**	**$157,230**	**80**	**X**	**75**
Project 16	**Repair**	**$46,288**	**45**	**X**	**75**
Project 18	**Repair**	**$107,700**	**8**	**X**	**74**
Project 19	**Repair**	**$200,482**	**200**	**X**	**74**
Project 20	Repair	$448,160	80	X	72
Project 21	Repair	$672,352	80	X	72
Project 22	Repair	$650,000	80	X	64
Project 27	**Repair**	**$94,000**	**45**	**X**	**69**
Project 28	Repair	$715,920	200	X	67
Project 30	Repair	$350,000	80	X	67
Project 31	Repair	$512,822	45	X	66
Project 33	**Repair**	**$60,863**	**8**	**X**	**65**
Project 34	**Repair**	**$60,000**	**45**	**X**	**65**
Project 35	**Repair**	**$84,646**	**8**	**X**	**64**
Project 36	Repair	$396,260	16	X	62
Project 37	Repair	$396,260	16	X	62
Project 40	Repair	$352,898	45	X	60
Project 41	**Repair**	**$146,000**	**45**	**X**	**60**
Project 43	Repair	$462,800	80	X	57
Project 44	**Repair**	**$116,350**	**8**	**X**	**57**
Project 46	**Repair**	**$88,057**	**16**	**X**	**57**
Project 47	**Repair**	**$160,509**	**45**	**X**	**57**
Project 50	**Repair**	**$76,320**	**8**	**X**	**55**
Project 51	**Repair**	**$71,331**	**8**	**X**	**54**
Project 52	**Repair**	**$85,122**	**8**	**X**	**54**
Project 53	**Repair**	**$189,640**	**16**	**X**	**54**
Project 54	Repair	$340,000	16	X	52
Project 55	**Repair**	**$82,838**	**8**	**X**	**52**
Project 56	**Repair**	**$82,838**	**8**	**X**	**52**
Project 57	Repair	$446,512	40	X	52

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 59	**Repair**	**$84,400**	**8**	**X**	**49**
Project 60	**Repair**	**$100,000**	**8**	**X**	**47**
Project 62	**Repair**	**$70,000**	**8**	**X**	**45**
Project 65	**Repair**	**$73,443**	**45**	**X**	**42**
Project 66	Repair	$97,222	8	X	42
Project 67	Repair	$250,000	80	X	40
Project 69	**Repair**	**$29,780**	**8**	**X**	**37**
Project 71	Repair	$477,718	16	X	32
Project 77	Repair	$82,098	80	X	2
Totals	**30 Proj Selected**	**$2,922,194**	**1,036**	**X**	**1,990**

Note. All repair projects were submitted for consideration. Projects selected by the model are bold.

The same method used in analyzing the new projects was used to analyze the repair projects. Thirteen more projects were submitted for consideration in the repair category than in the new category. While that may seem like a small number, repair projects had a starting budget of $3.2 million, dwarfing the possible available budget for new projects. This enabled more repair projects to be selected.

The top 11 projects based on their points were selected. This produced a value of 955 points, while only expending $1.16 million. The next three projects with the highest values were rejected by the model. Together they would have added an additional value of 208 points. The reason these projects were not selected was their overall cost of $1.77 million. These three projects alone cost more than the top 11 combined and only produce about a fifth of their combined value. This is another example of a project whose individual value to the organization is outweighed by the overall value that all of the projects selected provides. If those three projects had been selected, the overall value would have been significantly less.

It is also possible to compare projects in this category based on averages of cost and value added for selected and rejected projects. When comparing the projects, the selected projects had an average cost of $97,406 compared with the rejected projects, whose average cost was $415,688. The values these two categories offer follow the same pattern. The projects selected offer an average added value of 66.3 points instead of the average value added by the rejected projects of 54.3 points. This analysis shows that the selected projects provided the greatest value possible for the organization. The rejected projects both cost more and did not provide as great of a value to the organization as a whole, even though many of the rejected projects individually have a higher value.

3. Model and Organizational Comparison

The DPW looked at the results presented by the model and compared them to the projects they selected. The DPW chose to move the top-value projects to the contracting phase. Thus, the highest-value projects were selected by the organization. The available financial budget was assessed, and as many projects as possible with the highest value were selected. The DPW believes these are the most valuable projects to the organization. Table 11 shows the projects with the highest values that can be selected while keeping total costs below $3.2 million. It is important to note that a few projects were removed from by DPW; however, due to the timing of the removal of those projects, they were not deleted from the data presented in this analysis.

Table 11. DPW Project Selection Method Results

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 1	Repair	$200,000	80	X	104
Project 2	Repair	$40,118	45	X	115
Project 3	New	$31,664	45	X	98
Project 4	New	$70,000	45	X	95
Project 5	New	$135,171	45	X	93
Project 6	Repair	$100,000	45	X	92
Project 7	Repair	$110,000	45	X	92
Project 8	New	$120,000	45	X	92
Project 9	Repair	$71,195	45	X	89

Project Title	Project Type	Project Cost	Est. Eng. Hours	Est. Env. Hours	Project Value
Project 10	New	$330,000	80	X	87
Project 11	Repair	$60,464	45	X	87
Project 12	New	$86,736	8	X	80
Project 13	Repair	$72,580	45	X	78
Project 14	New	$109,136	45	X	78
Project 15	Repair	$157,230	80	X	75
Project 16	Repair	$46,288	45	X	75
Project 17	New	$250,000	80	X	74
Project 18	Repair	$107,700	8	X	74
Project 19	Repair	$200,482	200	X	74
Project 20	Repair	$448,160	80	X	72
Project 23	New	$181,618	80	X	72
Project 24	New	$129,727	80	X	72
Project 26	New	$92,623	45	X	69
Project 45	New	$44,920	8	X	57
Totals	**24 Proj**	**$3,195,812**	**1,369**	**X**	**1,994**

Analyzing the results produced by the DPW's selection method, the following information stands out. With 79 projects submitted for consideration, only 24 projects were selected by the DPW. Of the 24 projects selected, only 13 projects were the same as those selected by the model. This brings the total value of projects selected to 1,994 points, 343 points less than the 2,337 points produced by the model.

The weakness of the selection method used by the DPW is that it selects projects at a higher cost. The average cost of the projects selected was $133,158, compared with the average cost of $90,462 produced by the model. This cost difference allows the model to select 11 more projects, thus increasing the overall value to the organization.

The DPW chose a different selection method because it weighed the value of the individual project over the total value created by the selected projects. The DPW saw that the top-valued projects were the most important to the organization. An example given was that some of the smaller projects selected by the model were painting projects, while some of the more expensive projects dealt with major repairs and needed to be selected to move forward. This example also came into play when the financial constraint for new projects was broken. The DPW attempted to stay within the constraint but could break the constraint if they felt it was necessary, but the model could not select some of the new projects because they exceeded the financial constraint placed on the budget for new projects.

4. Side by Side Comparison

The tables previously presented show only one type of data, such as only showing new projects or only showing accepted projects. Table 12 shows a side by side comparison of the projects accepted by the model and the projects accepted by the organization. Projects highlighted are projects accepted by either the model or the organization, but not accepted by both.

Table 13 shows the projects rejected by both the model and the organization.

Table 12. Side by Side Comparison of Accepted Projects

Model Accepted Projects					Organization Accepted Projects			
Project Title	**Project Type**	**Project Cost**	**Project Value**		**Project Title**	**Project Type**	**Project Cost**	**Project Value**
Project 1	Repair	$200,000	104		Project 1	Repair	$200,000	104
Project 2	Repair	$40,118	115		Project 2	Repair	$40,118	115
Project 3	New	$31,664	98		Project 3	New	$31,664	98
Project 4	New	$70,000	95		Project 4	New	$70,000	95
Project 6	Repair	$100,000	92		Project 5	New	$135,171	93
Project 7	Repair	$110,000	92		Project 6	Repair	$100,000	92
Project 9	Repair	$71,195	89		Project 7	Repair	$110,000	92
Project 11	Repair	$60,464	87		Project 8	New	$120,000	92
Project 13	Repair	$72,580	78		Project 9	Repair	$71,195	89
Project 15	Repair	$157,230	75		Project 10	New	$330,000	87
Project 16	Repair	$46,288	75		Project 11	Repair	$60,464	87
Project 18	Repair	$107,700	74		Project 12	New	$86,736	80
Project 19	Repair	$200,482	74		Project 13	Repair	$72,580	78
Project 27	Repair	$94,000	69		Project 14	New	$109,136	78
Project 33	Repair	$60,863	65		Project 15	Repair	$157,230	75
Project 34	Repair	$60,000	65		Project 16	Repair	$46,288	75
Project 35	Repair	$84,646	64		Project 17	New	$250,000	74
Project 38	New	$60,000	62		Project 18	Repair	$107,700	74
Project 41	Repair	$146,000	60		Project 19	Repair	$200,482	74
Project 44	Repair	$116,350	57		Project 20	Repair	$448,160	72
Project 45	New	$44,920	57		Project 23	New	$181,618	72
Project 46	Repair	$88,057	57		Project 24	New	$129,727	72
Project 47	Repair	$160,509	57		Project 26	New	$92,623	69
Project 50	Repair	$76,320	55		Project 45	New	$44,920	57
Project 51	Repair	$71,331	54					
Project 52	Repair	$85,122	54					
Project 53	Repair	$189,640	54					
Project 55	Repair	$82,838	52					
Project 56	Repair	$82,838	52					
Project 59	Repair	$84,400	49					
Project 60	Repair	$100,000	47					
Project 62	Repair	$70,000	45					
Project 65	Repair	$73,443	42					
Project 69	Repair	$29,780	37					
Project 70	New	$43,717	35					
Totals	**30R/5N**	**$3,172,495**	**2,337**		**Totals**	**12R/12N**	**$3,195,812**	**1,994**

Table 13. Common Rejected Projects

Rejected by Both Model and Organization			
Project 21	Repair	$672,352	72
Project 22	Repair	$650,000	64
Project 25	New	$181,618	72
Project 26	New	$92,623	69
Project 28	Repair	$715,920	67
Project 29	New	$75,875	67
Project 30	Repair	$350,000	67
Project 31	Repair	$512,822	66
Project 32	New	$229,000	65
Project 36	Repair	$396,260	62
Project 37	Repair	$396,260	62
Project 39	New	$700,000	42
Project 40	Repair	$352,898	60
Project 42	New	$90,000	57
Project 43	Repair	$462,800	57
Project 48	New	$629,132	56
Project 49	New	$629,024	56
Project 54	Repair	$340,000	52
Project 57	Repair	$446,512	52
Project 58	New	$80,000	52
Project 61	New	$300,000	46
Project 63	New	$63,576	45
Project 64	New	$240,000	44
Project 66	Repair	$97,222	42
Project 67	Repair	$250,000	40
Project 68	New	$720,000	38
Project 71	Repair	$477,718	32
Project 72	New	$45,815	32
Project 73	New	$662,945	22
Project 74	New	$29,915	21
Project 75	New	$75,000	20
Project 76	New	$25,224	18
Project 77	Repair	$82,098	2
Project 78	New	$28,500	2
Project 79	New	$81,120	-2
Totals	**15R/20N**	**11,182,229**	**1,619**

VI. CONCULSION

This research examined the impact of adding an optimization model to the project selection process the DPW currently uses to select projects to move forward to the contracting phase. The department receives a large number of project requests every year. For analysis purposes, this research examined all project requests in the cost range of $25,000–750,000.

A mathematical model was created in Excel, designed around the constraints found to be common among a sample of projects the DPW handles. All of the data used were collected from project request forms submitted for approval for fiscal year 2013. The model was run and the results were analyzed to determine if the model operated correctly. The results were also analyzed to see if there would be any value gained by adding the model to the selection process.

The results of this research showed a couple of different things. First, the model itself ran as it was designed. It created the greatest value of projects selected based on the data collected and the constraints placed on the model. Second, while a solution was found based on the data collected, the results did not fully reflect what the organization found to be most important to it based on the projects selected to move to the contracting phase. This shows that the model currently being used needs some additional research. Finally, the model would add to the DPW's selection process because it offers another opinion about which projects should be selected, but it should only be used as a non-biased opinion.

A. RECOMMENDATIONS

Based on the performance of the model, I recommend that the values given to the projects be as realistic as possible and are fine tuned to create more separation between scores. Creating a value system with a greater separation between values (example: 3, 7, 15 instead of 3, 5, 8), would place greater value on the projects deemed important to the organization based on the desired criteria. This value system would provide better input to the model to use when making its selections.

Only four constraints were used in this model. A sample of projects should be reexamined to determine if any additional resources constraints were overlooked in the initial review for this research. In addition, this reexamination would provide feedback on the current constraints to determine if any can be removed.

I also recommend adding to the model a set of logical constraints. A set of logical constraints could serve in one of two ways. First a logical constraint could say that if one project is selected, another project should also be selected. An example of this would be two project requests submitted for painting of different areas in a building. The information would tell the model that if one of the paint projects is selected, the other paint project should be as well. It makes logical sense to select both projects. The second way a logical constraint could be used is to tell the model that if one project is selected, then another project should be rejected. Using the previous example, if a paint project is selected in a building, the project request to replace the floor should be rejected because the two projects would interfere with each other. There can be many other logical constraints which can be beneficially used to reflect reality and other considerations to ensure all parties involved are treated fairly.

B. FUTURE RESEARCH

This model is a starting point for developing a program that could aid in project selection for the DPW. The system for assigning values should be revamped and then studied again to determine if the model would better select projects, aligning it more closely to what the organization feels are the most beneficial projects.

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